Published May 2012

Report

Serious incident on **22 July 2011**
in cruise at FL350, north Atlantic Ocean
to the **Airbus A340-313**
registered **F-GLZU**
operated by **Air France**

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Ecologie, du Développement durable et de l'Energie

Foreword

This report expresses the conclusions of the BEA on the circumstances and causes of this serious incident.

In accordance with Annex 13 to the Convention on International Civil Aviation and with European Regulation n° 996/2010, the investigation was not conducted so as to apportion blame or to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents.

Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

SPECIAL FOREWORD TO ENGLISH EDITION

This report has been translated and published by the BEA to make its reading easier for English-speaking people. As accurate as the translation may be, the original text in French is the work of reference.

Table of Contents

Synopsis

Date
22 July 2011 at 1 h 00 UTC[1]

Place
In cruise at FL350, North Atlantic ocean near position 18N 060W

Type of flight
Public transport
Scheduled international passenger flight

Aircraft
Airbus A340-313 registered F-GLZU

Operator
Air France

Persons on board
Captain (PF)
2 co-pilots (PNF) ; 11 cabin crew
270 passengers

[1] Except where otherwise stated, the times shown in this report are expressed in Universal Time Coordinated (UTC).

1 - HISTORY OF FLIGHT

Note: The following elements are based on recorded data in the FDR and the direct access recorder (DAR) as well as statements. The event was not available on the cockpit voice recorder (CVR).

The crew took off from Caracas-Maiquetía Simón Bolívar airport at 23 h 38 for Paris Charles de Gaulle. The captain was PF.

At 23 h 52, climbing through FL180, the PF and the PNF both set the range of their Navigation Display (ND) to 320 NM.

Between 0 h 28 and 0 h 47, the PNF modified the range of his ND several times between 20 and 320 NM, and then kept the latter adjustment. The crew indicated that the weather radar, set to maximum gain and a tilt between -0.5° and -1°, did not detect any precipitation[2]. The aeroplane was stable at FL350, in clear air, and at a cruise Mach of 0.83. Autopilot (AP) n°1 and the auto-thrust (A/THR) were engaged. The weather radar mode was set to “WX”.

At 1 h 00 min 24 (point n°1 on Figure 1), about 2 NM after passing coordinates 18N 60W, the aeroplane entered a zone of moderate turbulence. The overspeed warning (“OVERSPEED”) was triggered[3] and the “Master Warning” warning light came on. The crew stated that they were very surprised by this warning. Mach reached 0.87.

[2] The gain and tilt are not recorded parameters. The crew remembered, without being able to confirm with certainty, that the tilt was alternately set between -0.5° and -1°.

[3] Maximum operating Mach (MMO) was 0.86. The OVERSPEED warning was triggered at MMO+0,006, that is Mach 0.866. During the event, the high speed protection was not activated.

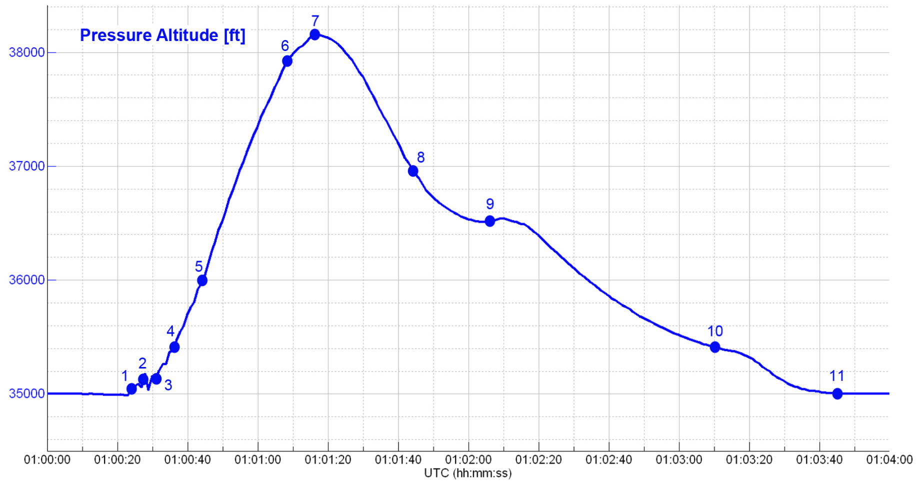


Figure 1 - Vertical flight path

At 1 h 00 min 27 (point n°2), the PNF manually disengaged the AP by pressing the takeover pushbutton on the side-stick. A pitch-up input on the PNF's side-stick going as far as ¾ to stop was recorded for 6 seconds. This input was accompanied by an input to bank to the right then left. The PNF stated that he did not remember these inputs.

From the start of the pitch-up input until point n°9, the high angle of attack protection was activated several times (see the detail of the activation periods in the appendix).

At 1 h 00 min 28, Mach was 0.84 and the OVERSPEED warning ceased for 2 seconds. It reappeared again for one second, and then disappeared again. The aeroplane climbed at a vertical speed of 1,950 ft/min.

At 1 h 00 min 30, the "Master Warning" warning light went off. The crew selected a Mach of 0.76 for 3 seconds, then 0.85.

At 1 h 00 min 31 (point n°3), the PF extended the speedbrakes. Mach was 0.84 and started to decrease 2 seconds later.

The PF indicated that in the seconds that followed, he switched on the lights and noticed being in IMC and that there was precipitation. He also indicated that he turned round to put his meal tray on the seat behind him and to take the Public Address handset to make a passenger and cabin crew announcement. The handset slipped from his hands. The PNF recovered it and used it to make the announcement.

At 1 h 00 min 32, the altitude went above 35,200 ft. The crew stated that they did not remember hearing the "Altitude alert" warning, which is triggered if the current altitude is 200 ft above the selected altitude. Pitch attitude increased, moving from 3° to 9° in 5 seconds.

At 1 h 00 min 37 (point n°4), the speedbrakes started to retract automatically. Pitch attitude then varied between 8° and 10°.

At 1 h 00 min 44 (point n°5), the aeroplane was at FL360. The speedbrakes were retracted. Pitch attitude increased to about 12° in 2 seconds. The aeroplane continued to climb and Mach decreased.

The PF stated that he had noticed that the speed was low. Shortly afterwards, at 1 h 00 min 47, the crew selected Mach 0.93. The aeroplane was still climbing with a vertical speed which reached a maximum of 5,700 ft/min. The crew was not aware of this. The N1's were at 100%.

At 1 h 00 min 48, the PF switched the range of his ND to 160 NM.

At 1 h 00 min 53, the PNF pressed the Master Warning light. Altitude was 36,900 ft.

At 1 h 01 min 08 (point n°6), while the aeroplane was at 37,950 ft in climb, the PF disengaged the A/THR and moved thrust levers forward to the TO/GA detent.

At 1 h 01 min 17 (point n°7), altitude reached maximum: 38,150 ft. Mach was 0.66.

The PF stated that he noted with surprise that altitude was 38,000 ft and asked the PNF if they were cleared for FL350.

At 1 h 01 min 42, while the aeroplane descended past 37,000 ft and the selected altitude was 35,000 ft, the PF pulled the altitude selection knob (ALT knob), which engaged the OPEN DES longitudinal mode. The PF stated that he wanted to order the AP to re-descend to FL350, but that "nothing was displayed on the PFD"[(4)]. The indicated airspeed was 226 kt, or 19 kt below VLS[(5)]. The 2 flight directors (FD) then disappeared[(6)] (point n°8). At the same time the PNF carried out transmissions for one minute on HF1 with the New York en route control centre in order to inform them of the level bust and the turbulence encountered.

At 1 h 02 min 06 (point n°9), the aeroplane descended past 36,520 ft. The PF then became aware of the disengagement of the AP and made a pitch-down input on his sidestick. Pitch attitude began to decrease 2 seconds later.

From 35,400 ft (point n°10), the PF re-engaged AP1, altitude stabilised at FL350 (point n°11), and A/THR was re-engaged.

At 1 h 25 min 38, an ACARS message received from the Air France OCC indicated that there was nothing visible 10 NM north of the 18N 60W position on the satellite photo at 1 h 00 and that no clear air turbulence was forecast at that point either.

The flight continued without further incident to Paris-Charles de Gaulle airport, where the crew landed at 8 h 33.

(4)The AP was still disengaged at that moment.

(5)Minimum selectable speed.

(6)When the flight directors (FD) are engaged in OPEN DES mode, with the AP disengaged and speed is below VLS-2 kt, the automatic descent speed protection is triggered. The FD then disengages and the cross bars disappear on the PFD. An aural "triple-click" warning is triggered.

2 - ADDITIONAL INFORMATION

2.1 Meteorological Conditions

The data available to the crew did not show any significant phenomenon on the route roughly as far as the middle of the Atlantic.

However, infra-red satellite images obtained by the BEA from Météo-France showed the presence of isolated cumulonimbus of moderate intensity between 0 h 30 and 1 h 30 in the area around point 18N 60W, with the top situated at FL380[7]. The recorded trajectory showed that the aeroplane flew close by these clouds during the event.

[7]According to the Météo-France "Arpège" model valid on 22 July at 00 UTC.

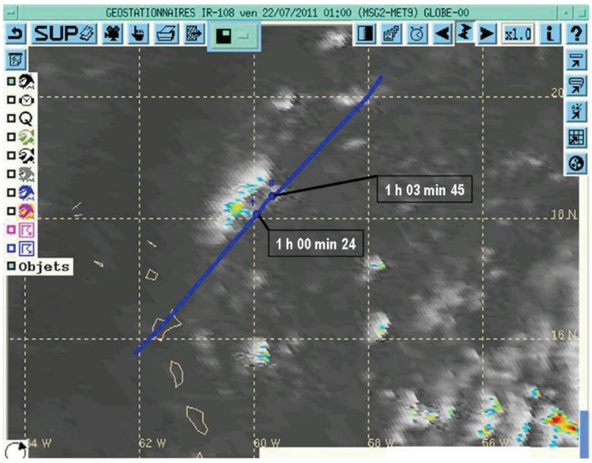


Figure 2 – Trajectory on IR image at 1 h 00

It should be noted that this type of isolated cloud in an inter-tropical zone is beyond forecasting abilities other than immediate or very short term forecasts.

The crew of another Air France flight, about 40 minutes behind F-GLZU at the same level (FL350) and on a virtually parallel route, was able to look for then observe a series of echoes in this zone.

2.2 Weather Radar

F-GLZU was equipped with Rockwell Collins weather radar. The radar image obtained depends on 3 parameters: the gain, the tilt (angle between the horizontal and the middle of the radar beam) and the ND range. The radar aperture is 1.7° above and below the selected tilt.

Weather radar is designed to detect water in liquid form (rain or wet hail), by measuring the rate of precipitation. According to the rate detected and the selected gain, echoes of different colours are presented on the ND. It hardly detects water in solid form, such as ice crystals or dry snow.

The tilt adjustment determines the zone scanned by the radar beam and consequently the echoes that are detected and displayed on the ND. Adjustment of the gain then enables the reflectivity of the precipitation encountered to be adapted. It should be noted that clouds situated in front of the aeroplane but not swept by the beam are not visible on the radar:

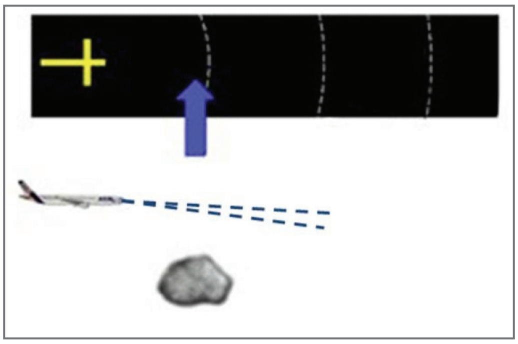


Figure 3 - Example of radar image

In addition, the structure of cumulonimbus requires an adjustment of the tilt and range as the aeroplane approaches a convective cell. Indeed the reflectivity of precipitation inside a cumulonimbus depends on the temperature.

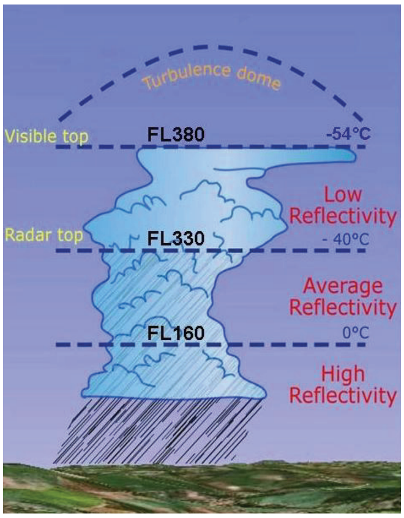


Figure 4 - Cumulonimbus radar reflectivity

The most reflective zones (liquid precipitation) are located under ISO 0°C. The reflectivity is higher there.

Between ISO 0° and ISO -40°C (called "radar top"), reflectivity is average, and depends on the liquid water/ice crystals ratio.

When the temperature is below -40°C, the reflectivity is very low (ice crystals).

On the day of the event, the Météo France data indicated that the visible top of the clouds corresponded to FL380, ISO -40°C at FL 330 and ISO 0°C at FL160.

The tilt is adapted to the range of the ND. The manufacturer's Flight Crew Training Manual and the Air France FCOM A330/A340 manual recommend setting the range in cruise to 160 NM or 80 NM.

The FCTM indicates that in cruise the tilt must be set so that the ground returns only appear within the most distant circles. The same setting principle is covered in the Air France FCOM manual for cruise above 20,000 ft.

Neither of these 2 documents indicates explicitly the numerical values of tilt according to the range. However an Airbus Flight Operations Briefing Note[8] indicates a range of magnitude of tilt values to use in cruise according to the range:

[8] Reference FOBN: FLT_OPS-ADV_WX – SEQ 07 – REV 02 – FEB. 2007

Range of ND	Tilt (°)
320 NM	-1.0
160 NM	-1.5
80 NM	-3.5
40 NM	-6.0

The recorded data indicated that no return could have appeared on the PNF's ND between 00 h 29 and 00 h 46, as the convective zone was beyond the ND range. After that, calculations showed that a tilt set to -1° enabled in theory the appearance of a return on the 2 ND until about 0 h 48, as the beam scanned the zone of increased reflectivity. Afterwards, even with an adequate range, the beam went further and further from the zone of high reflectivity. With a tilt set at -0.5°, the possibility of a return on the ND was low as the beam never crossed the zone of high reflectivity.

2.3 High Angle of Attack

In manual flying and normal operation conditions, longitudinal control is performed according to the "normal" flight control law. The pitch inputs on the sidestick command the elevators and the THS to maintain a load factor according to the sidestick travel. With the sidestick in neutral, wings horizontal, the system maintains a vertical load factor of 1 g in such a way that the trajectory is maintained constant. Adjustment of the THS is automatic.

In normal law, when the angle of attack exceeds a threshold called "Alpha Prot", the elevator and THS control change to a protection mode where the angle of attack is proportional to the position of the side stick. The ordered angle of attack cannot exceed a limit called "Alpha MAX", even if the sidestick is put into pitch up stop position. If the sidestick is released, the angle of attack decreases and is maintained at Alpha Prot.

If the angle of attack becomes greater than Alpha MAX while the speedbrakes are extended, they then retract automatically.

Furthermore, the value of Alpha Prot depends on the Mach and the position of the speedbrakes: when the Mach increases as far as MMO (0.86), the value of Alpha Prot decreases.

The high angle of attack protection has priority over all other protections.

To exit the high angle of attack protection:

- The sidestick must be moved more than half of the travel forward, or
- The sidestick must be pushed for at least 1 s when the angle of attack is less than Alpha MAX or,
- The sidestick must be in neutral or pushed, for at least 0.5 s when the angle of attack is less than Alpha Prot.

2.4 Behaviour of the Aeroplane in the Longitudinal Plane

Digital simulations carried out by Airbus at the BEA's request as well as tests in a flight simulator were able to highlight that:

- The behaviour of the aeroplane during the event flight corresponded to that of the digital model;
- If the AP had not been manually disengaged, it would have remained engaged; there would not have been a significant trajectory deviation, with a gain in altitude of about 200 ft.

Note: Without the high angle of attack protection, the aeroplane would have kept its ascending trajectory until the triggering of the stall warning.

A detailed breakdown of the aeroplane's behaviour during the level bust is in the appendix.

2.5 Messages and Warnings

The recorded data showed that the AP was disengaged by the AP takeover pushbutton located on the right sidestick. This disengagement by pressing the takeover pushbutton triggers an aural warning called "Cavalry Charge" to sound for 1.5 seconds maximum, activates the "Master Warning" flashing light for 3 seconds maximum, and displays the amber "AP OFF" message for 9 seconds on the ECAM. In addition, the "AP1"[9] display disappears from the FMA strip. It is possible to cancel the visual and aural warnings before the end of their maximum duration by pressing the AP takeover pushbutton again on the side stick.

[9]AP n°1 was engaged during the event.

The "OVERSPEED" condition generates a "Master Warning", which cannot be cancelled by just pressing the "Master Warning" warning light. The aural warning corresponding to an "OVERSPEED" is a CRC[10]. It has priority over the AP disengagement warning.

[10]Continuous Repetitive Chime.

The altitude alert aural warning, called "C-chord" or "Altitude alert" sounds in particular when current altitude is 200 ft above the altitude selected on the FCU. This does not lead to the illumination of the "Master Caution" warning light, or the "Master Warning" warning light. However, pressing the latter enables a "C-chord" to be switched off. This altitude deviation also causes the flashing of a frame around the altitude display on the PFD.

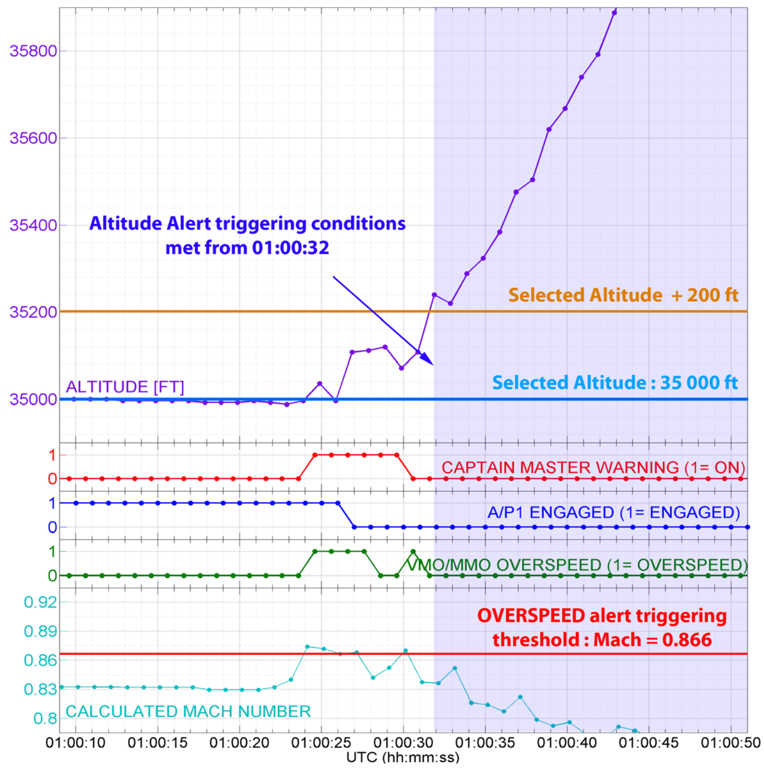


Figure 5 - Warnings recorded

The recorded data showed that there was initially an OVERSPEED warning, which generated a CRC aural warning. This warning was active as long as the Mach was greater than 0.866.

Three seconds later, the AP was disengaged, but as the CRC was still active, the "Cavalry Charge" aural warning was not generated, as it was masked by the CRC. While it was not generated, it could not be cancelled by a possible 2nd press on the sidestick takeover pushbutton.

The moment the 1st OVERSPEED stopped corresponded to the end of the 1.5 second maximum sounding of the "Cavalry Charge", which was therefore not activated. The "Master Warning" continued to be active between the 1st and the 2nd OVERSPEED as the disengagement of the AP generates a "Master Warning" of 3 seconds if it is not cut off.

The moment of theoretical triggering of the "C-chord" warning, at 35,200 ft, was one second after the end of the 2nd OVERSPEED. Pressing the "Master Warning" warning light, at 36,900 ft, the PNF cancelled the "Altitude alert" about 20 seconds after it appeared. In the absence of a CVR recording, it was not possible to confirm what the real duration of the "C-chord" warning was.

The Airbus A340-313 was certified in March 1995, according to the standards in force at that date[11]. These standards did not specify that the AP disengagement warning should be cancelled by the pilot in the event of an intentional disengagement.

The current certification standards of the CS25[12] require that the warnings be easily detectable and intelligible by the crew in all foreseeable operating conditions, including when several warnings sound. A ranking of warnings is also to be defined, in order to mask or shut off a warning considered of lower priority than another.

[11] JAR25 (change 13).

[12] CS-25 Amendment 11, paragraph CS 25.1322(a)(2) and (c)(1).

The means of compliance for this specification indicate that if the condition which triggered the interrupted warning is still fulfilled, this warning may be repeated once the warning with the highest priority has ceased. Furthermore, the means of compliance for specification CS 25.1329(j) specify that the AP disengagement warning should be continuous until cancelled by one of the pilots. This can be done by pressing a second time on the sidestick takeover pushbutton, or by re-engaging the AP or by any another acceptable means.

On recently certified public transport aeroplanes like the Boeing B787 or the Airbus A380, the AP disengagement warning sounds as long as it is not cancelled by one of the pilots.

2.6 Personnel Information

2.6.1 Captain

Male, aged 48

❐ ATPL License

❐ Airbus A340 type rating issued on 17 February 2007 and extended on 19 January 2011

❐ Experience:

- Total: 23,226 flying hours, of which 3,081 on A330/A340 types
- In the previous three months: 181 hours on Airbus A330/A340
- No flights undertaken from 13 to 19 July 2011
- Flight from Paris-Charles de Gaulle to Caracas on 20 July 2011
- Last CRM training (« 4S ») undertaken 17 December 2010

2.6.2 Copilot on duty at the time of the event

Male, aged 50

❐ ATPL License

❐ Airbus A340 type rating issued on 10 May 2006 and extended on 17 April 2011

❐ Experience :

- Total: 9,647 flying hours, of which 2,410 on A330/A340 types
- In the previous three months: 140 flying hours on Airbus A330/A340
- No flights undertaken from 17 to 19 July 2011
- Flight from Paris-Charles de Gaulle to Caracas on 20 July 2011
- Last CRM training (« 4S ») undertaken 15 April 2011

3 - LESSONS LEARNED AND CONCLUSION

3.1 Use of weather radar

Use of the radar requires the pilots to have a good knowledge of the structure of cumulonimbus, understanding of the operating principle of radar, active monitoring and constant interpretation of the images displayed. In particular, an adapted management of tilt is essential to correctly estimate and assess the vertical development of cumulonimbus. Incorrect adjustment of the tilt can lead to cumulonimbus not being shown on the radar display whereas they are visible to the naked eye.

The adjustment of the weather radar was not the most suitable for detecting the convective zone crossed. Indeed, the ranges selected remained at 320 NM for a considerable time, whereas the airline's FCOM manual recommends 160 NM or 80 NM. This probably contributed to the crew's failure to detect the convective cell close to point 18N 060W.

It should be noted that choosing the 320 NM range on the ND may come from the practice of adapting the range to see the next waypoint on the ND. In the zones where the waypoints are distant from each other, this practice goes against optimal utilisation of the weather radar.

Neither the airline's FCOM A330/A340 manual or the FCTM proposed by the manufacturer show numerical values of tilt to use in cruise according to the range. Only the technique of adjusting tilt so that the ground returns appear in the upper part of the ND features in these 2 documents. The tilt orders of magnitude to use in cruise are, however, available in the Airbus "Use of weather radar" FOBN. The absence of such orders of magnitude in the operator's FCOM manual may contribute to the inadequate use of weather radar.

3.2 Aural Warnings

A large part of long haul flights occurs in cruise, when most tasks relate to flight parameter monitoring, navigation management and weather surveillance. Routine may set in during these usually calm periods. When an unexpected aural warning is triggered, it may generate a momentary period of stress ("startle effect") and surprise.

The "startle effect" generated by a sudden event such as an aural warning may produce a "reflex" type reaction with some pilots. Sometimes this effect sparks primal instinctive reaction, instant and inadequate motor responses. These basic reflexes may prove to be incorrect and difficult to correct under time pressure and may affect the pilot's decision-making ability.

The surprise effect typically occurs when there is a difference between the mental representation that the pilot has of the aeroplane's behaviour and its real behaviour (instrument failures, trajectory upset) or when an unexpected event occurs. Its intensity depends on the severity, frequency and predictability of the event, as well as the previous experience of the crew.

In some cases the surprise effect may lead to:

- Disturbance of memorisation mechanisms,
- Reduction or loss of situational awareness,
- Forgetting procedures,
- Absence of reaction or an over-long reaction time.

Recent studies showed that the surprise and "startle" effects are currently the subject of little or no simulator training.

The PNF, probably surprised by the "OVERSPEED" warning as well as by the unanticipated turbulence, experienced a "startle" effect. He briefly pressed the AP takeover pushbutton on his sidestick, then made a pitch-up input for 6 seconds, probably as a reflex action and without realising it. The AP disengagement aural warning, which should last 1.5 s, was masked by the OVERSPEED aural warning, the latter having priority. The crew did not see the various changes in display (amber ECAM "AP OFF" message, disappearance of the "AP1" display from the FMA strip). For nearly one a half minutes the crew was not aware that the AP had been disengaged. The fact that the AP disengagement aural warning never sounded contributed greatly to this situation. Indeed, if the warning had sounded after the OVERSPEED had ceased and/or if the crew had had to carry out an action to cancel the AP disengagement warning, then perception of the disengagement of the AP would have been easier.

The "Master Warning" warning light remained on for 6 seconds. The level bust aural warning ("Altitude Alert ") probably sounded for about twenty seconds, before being cancelled by the crew by pressing the "Master Warning" warning light. The surprise effect and the alteration of memorisation mechanisms that it can produce probably contributed to the fact that the crew did not remember hearing the "Altitude Alert". The frame around the altitude display on the PFD started to flash during the same period of time.

The aeroplane was equipped with a CVR with a recording capacity of 2 hours. Given that the incident took place nearly 8 hours before landing at Paris-Charles de Gaulle, the CVR no longer contained the recordings relating to the event. This prevented confirmation by the CVR of the order and masking of the aural warnings.

3.3 Monitoring of Flight Parameters and CRM

The "Severe turbulence" procedure in the manufacturer's QRH (Quick Reference Handbook) is the following:

SIGNS	ON
AUTO PILOT	KEEP ON
A/THR (when thrust changes become excessive)	DISCONNECT

The Air France QRH procedure allows for 2 additional items before the item checking the condition of the AP:

- ❒ Switch on the "fasten seatbelts" sign,
- ❒ Warn the cabin crew,
- ❒ Warn the ATC if the aeroplane is in RVSM airspace,
- ❒ Check that the AP is engaged,
- ❒ Select a speed lower than or equal to the recommended speed according to the flight level and mass,
- ❒ Disconnect A/THR and adjust the N1 to the recommended value according to the flight level and mass.

The crew was initially engaged in turning round to put down a meal tray and take the Public Address handset. Consequently, the PFD was out of visual range of the 2 pilots for these few seconds. The PF's attention was then drawn to observation of the meteorological situation, looking first outside to note the precipitation, then modifying the range of his ND. The PNF's attention was drawn to the announcement to the cabin crew. This prioritisation occurred at the expense of monitoring essential parameters such as pitch angle, altitude and the FMA strip during the climb phase. Neither pilot was aware that the AP had been disengaged. The following visual displays were not detected (see Figure 6):

- ❒ Nose-up attitude, which had reached 12° pitch up,
- ❒ High vertical speed, which had reached 5,700 ft/min,
- ❒ The flashing frame around the altitude display on the PFD when the altitude passed 35,200 ft,
- ❒ The position of the FD cross bars,
- ❒ Altitude until it reached more than 38,000 ft,
- ❒ The "AP1" display which had disappeared from the FMA strip,
- ❒ The amber ECAM "AP OFF" message which remained displayed for 9 seconds after the AP disengagement.

Figure 6 - Reconstitution of display on the PFD during climb at 01 h 00 min 49

It should be noted that perception of these displayed items was made more difficult due to the absence of specific corresponding aural warnings and the level of turbulence which made instrument reading more difficult.

The PF's attention was again focused on the flight parameters for about ten seconds before reaching maximum altitude. He then noted that the altitude was 38,000 ft. It was only approximately 30 seconds later that he realised that the AP was disengaged.

Analysis of numerous events encountered during severe turbulence indicates that unfavourable consequences may be minimised if the crew uses the automated systems appropriately. The manufacturer's recommendation consists of maintaining the AP connected and avoiding an instinctive reaction to take control manually.

The F-GLZU recorded data showed that the AP would have remained connected if it had not been manually disengaged. A digital simulation carried out at the BEA's request showed that the gain in altitude would then have been limited to 200 ft.

Because of the absence of CVR recording, it was not possible to evaluate CRM in order to explain the lack of monitoring of the basic parameters and the flight path.

3.4 Conclusion

This serious incident was due to inadequate monitoring of the flight parameters, which led to the failure to notice AP disengagement and the level bust, following a reflex action on the controls.

The following factors contributed to the serious incident:

- The AP disengagement aural warning was not broadcast, because of simultaneity with the "OVERSPEED" warning with higher priority.
- The turbulence encountered at the start of climb made parameter reading difficult.
- Checking AP engagement, as required in the operator's "Severe Turbulence" procedure, was not carried out.
- Inappropriate use of the weather radar meant it was not possible to avoid entering a zone of turbulence.

4 - RECOMMENDATIONS

Note: In accordance with European Regulation n° 996/2010 on accident investigations, a safety recommendation in no way constitutes a presumption of fault or responsibility in an accident or incident. Article R.7312 of the French Civil Aviation Code and European Regulation n°996/2010 stipulate that the addressees of the safety recommendations shall inform the BEA (the French civil aviation accident investigation body), within 90 days of reception, of the actions they intend to take and the time necessary for their completion, and where no action is taken, the reasons for this.

4.1 Training in Parameter Monitoring during Turbulence or Overspeed

The investigation showed that following the occurrence of turbulence and an overspeed situation, inadequate parameter monitoring led to the failure to detect essential information, such as the disengagement of the AP and the level bust. This was probably due to the surprise effect that led to a reflex action on the controls by the PNF and led to a lowering or loss of situational awareness by the crew. Recent studies show that surprise or "startle" effects are currently the subject of little or no simulator training.

Consequently, the BEA recommends that:

❍ **EASA introduce the surprise effect in training scenarios in order to train pilots to react to these phenomena and work under stress. [Recommendation FRAN-2012-021]**

4.2 AP Disengagement Warning

The Airbus A340 AP disengagement warning is designed to sound for only 1.5 seconds maximum if the disengagement results from pressing the button on one of the sidesticks. If a warning with higher priority is active during this time, the AP disengagement warning may be cancelled or even never sound. This was in compliance with the standards in force in March 1995, during certification of the A340.

Since 27 December 2007, the means of compliance relating to standard CS 25.1329(j) have specified that the AP disengagement aural warning should continue until silenced by one of the pilots. This can be done by pressing the button on the sidestick again, or by re-engaging the AP or by any other acceptable means. Furthermore, since 4 July 2011, the means of compliance relating to standard CS 25.1322 have indicated that if the condition that triggered the suspended warning is still met, this warning may be repeated once the higher priority warning has ceased.

The investigation showed that the absence of the AP disengagement aural warning contributed to the serious incident.

Consequently, the BEA recommends that:

❍ **EASA evaluate the possibility of requiring that the autopilot disengagement aural warning for all aeroplanes of a maximum mass on take-off of more than 5.7 t be triggered in compliance with paragraphs AMC 25.1322 and AMC 25.1329(j) of the CS-25. [Recommendation FRAN-2012-022]**

4.3 Training in the Use of Weather Radar

The use of radar requires pilots to possess sound knowledge of the structure of cumulonimbus, and understand the operating principle of radar. This also requires active monitoring, especially at night and in IMC or in certain areas, and constant interpretation of the images displayed. The investigation showed that the crew's setting of the weather radar was not optimal, which contributed to the occurrence of the serious incident.

Consequently, the BEA recommends that:

- **The DGAC ensure that operators provide training and practice to their crews enabling them to improve their use of weather radar. [Recommendation FRAN-2012-023]**

- **The DGAC request that operators check, for example in the context of flight analysis or LOSA, that the use of weather radar is in accordance with procedures or best practices. [Recommendation FRAN-2012-024]**

4.4 Absence of CVR Data for Incidents

The aeroplane was equipped with a CVR with a recording capacity of 2 hours. As the incident took place almost 8 hours before landing at Paris-Charles de Gaulle, the CVR no longer contained the cockpit voice recordings relating to the event. Significant elements of the investigation could not therefore be confirmed by the CVR.

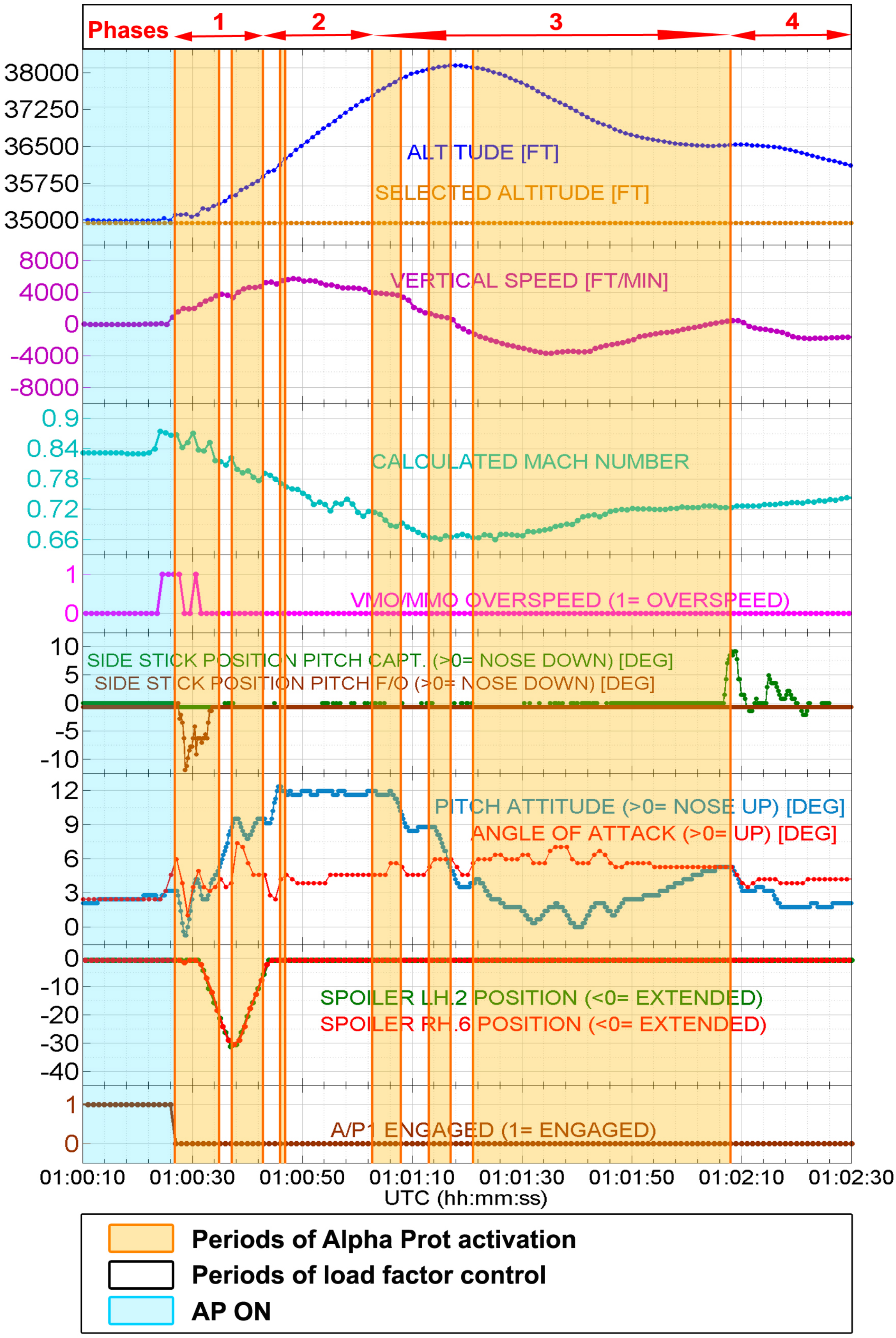
Determination of the causes of a large number of incidents, including some serious incidents, has been limited, indeed even compromised by the lack of conservation of cockpit voice recordings of the flight phases concerned, mainly due to limited recording capacity, in particular on long-haul flights. Furthermore, regulatory constraints that prohibit flying without a CVR (except in specific cases of failures) do not encourage operators to penalise their operation for the requirements of an investigation.

The majority of CVR's now offer a recording capacity of 2 hours, or 30 minutes for the oldest types. The traditional 30-minute CVR duration is probably linked to the technical limitations of use of magnetic tape. The 2-hour maximum capacity of current recorders may be linked to the limits of flash memory available at the start of their entry into service. However, the technological development of these systems now allows recording capacities of at least 10 hours. CVR's with such capacities are already available on the market.

Consequently, the BEA recommends that:

- **EASA and ICAO require that the minimum recording duration of CVR's be increased to allow the recording in full of long-haul flights. [Recommendation FRAN-2012-025]**

The level bust can be divided into 4 phases:



- Phase 1: Initially, a gust of headwind[(1)] generated overspeed and the activation of the "OVERSPEED" warning. A few seconds later, a rising gust caused an increase in the angle of attack and vertical speed. Then, the PNF disengaged the autopilot and made a pitch-up input for 6 seconds while the PF extended the speedbrakes. From the start of the pitch-up input, the angle of attack being greater than Alpha Prot, the high angle of attack protection was activated. Then, for 2 seconds, the angle of attack moved briefly below Alpha Prot, with the sidestick in neutral, which meant it exited the protections. The combined effects of turbulence, sidestick input and the extension of the speedbrakes led to increases in pitch, vertical speed and altitude. An angle of attack spike greater than Alpha Prot activated the high angle of attack protection again. The angle of attack continued to increase and passed Alpha MAX, which caused the automatic retraction of the speedbrakes.

- Phase 2: The intensity of the turbulence decreased and the angle of attack again became less than Alpha Prot (except for 2 seconds). In the absence of sidestick input, the high angle of attack protection deactivated. The load factor control law then maintained the rising trajectory of the aeroplane. During the climb, since the vertical speed exceeded the capacity to climb at constant speed, the aeroplane speed decreased. When lift became less than weight, the pitch decreased. Maintaining the load factor at 1 g induced a slight increase in the angle of attack.

- Phase 3: The high angle of attack protection was activated again (except for 9 seconds). In the absence of input on the sidesticks, the angle of attack was therefore maintained at Alpha Prot value. The decrease in flight path angle was accompanied by a decrease in pitch. Aeroplane altitude reached 38,152 ft before decreasing.

- Phase 4: The angle of attack was equal to Alpha Prot therefore less than Alpha MAX. Consequently, the PF's pitch-down input for more than one second on the sidestick caused the high angle of attack protection to be exited and the longitudinal control law returned to load factor. The pitch attitude decreased then stabilised until the crew re-engaged the autopilot.

[(1)]Digital simulations showed that the turbulence encountered during the event was mainly characterised by a gust of headwind of 25 kt followed a few seconds later by a rising gust of 35 kt. A second rising gust of 15 kt occurred roughly 10 seconds later. The total duration of the turbulence was approximately one minute.

BEA

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

200 rue de Paris
Zone Sud - Bâtiment 153
Aéroport du Bourget
93352 Le Bourget Cedex - France
T : +33 1 49 92 72 00 - F : +33 1 49 92 72 03
www.bea.aero